actual space it has occupied for ages. This rock is like hard glass, elastic, which involves compressibility. At last the compressive stress accumulating for ages becomes too great to be borne without relief, which can come only from fracture.

The fracture, once started, extends from its initial point in lines of dislocation, as is in cold countries constantly observed in the thick ice covering lakes, and as is seen in the heated pane of glass.

But the commotion, the shock, the rending, the noises, are infinitely greater than in the case of the pane of glass or the sheet of ice. In the sudden splitting, rending, and jarring dislocation of the glass, we have the working model of the heated strata of rock. If the effect bears any proportion to the relative magnitude of the model and the rock, then we have force, stress, movement, noise enough to produce all the audible and visible effects of the Charleston earthquakes.

The sudden dislocation and displacement under Charleston may produce the local shock; the noise of the sudden splitting of the rock in place, the sound like distant cannon-shot. The long roar and grinding, like ten thousand rusty iron chariots on a rocky road, may be due to the production of a crack, which, if ten miles long, and instantaneous throughout its whole length, would yet be heard only as the sound from each foot of its length arrived at the ear of the hearer. The sound produced under foot might be heard within a few seconds; and that produced fifty or sixty thousand feet away, say ten miles, would not reach the ear till it was fifty or sixty seconds old; and, as the sound of successive portions breaking at different distances arrived, there would result a continuous and heavy roar. Such a dislocation would relieve in great measure the general, the widely diffused stress and strain. But movements would be local as well as general, and the smaller but still immense sections of our stratum of rock might continue for days and weeks to adjust themselves by smaller cracks, crushings, and dislocations, producing the lesser shocks, sounds, and roars which commonly follow the first and greatest disturbance. Such have followed that of Charleston and Summerville. In fact, the pane of thick glass breaking over the flame of an alcohol-lamp in the laboratory or on the lecture-table seems to give a working model, illustrating all the known and reported phenomena of the Charleston earthquake. The heat supposed to be observed by some in the ejection of water and mud may well have come from the sudden compression and stresses set up in the moment of dislocation. Sudden shocks, compressive stresses, and motion arrested, produce heat, as, when a fifteen-inch cast-iron ball at great velocity breaks to pieces against an iron target, its scattered fragments are all hot to the hand that gathers them. Ten miles square of hard limestone, if heated 10°, would expand three feet in length and width if free to move; heated 100°, it would expand about thirty feet each way. Here are force and movement enough to wreck a dozen Charlestons. All we need on this theory is a change of temperature not very great nor rapid.

Such changes are plainly registered in the famous three columns of Pozzuoli described by Lyell, which, having been erected above the level of the ocean, have, two or three times within the historic period, sunk below its surface, and been bored at various levels by stone-boring shell-fish (Simaceae saxophagi), and then risen again till these marks, undoubtedly made under water, are now above the water, which merely bathes the floor of the temple, and on which they still stand upright, as though never disturbed. Lyell's clear description assigns these evident changes of level to local changes of temperature in the crust of the earth below Pozzuoli. Visible motion and fracture of rocks also accompany the phenomena of 'creeping' in coal-mines. M. C. MEIGS.

Washington, D.C., Oct. 20.

Sea-level and ocean-currents.

I have just received a letter from my friend, Capt. John Brown, son of John Brown the martyr, which I have thought would interest your readers in itself, and furnish a better illustration than I have before given of the power of wind-friction to move great bodies of water. I therefore enclose you the following copy: —

PUT-IN BAY IS., Oct. 16, 1886.

MY DEAR FRIEND, — At 11 o'clock Thursday evening, the 14th inst., I witnessed here a remarkable fact, the effect of the late tremendous wind-storm. This commenced about 7 A.M., and began to let up at 11 o'clock in the evening, or a little later. I then went down to the shore in front of my house, and found the lake lower than the average by fully six feet! This is the greatest depression from such cause I have noticed during a residence here of nearly twenty-four years. We have not, within this period, had such a high wind steadily continued for so long a time.

The captain of the steamer Chief Justice Waite, running between Toledo and the islands, reports the fall of water-level at Toledo as about eight feet.

Ever yours, JOHN BROWN, JR.

The reply of Mr. Ferrel, contained in *Science* of July 30, seems to me to obscure rather than illuminate the subject it discusses. The question before us is, not whether the wind has the power of raising the water-level on a coast, but whether wind-friction can, in the great equatorial belt and in the track of the Gulf Stream, produce the flow of water which is there observed. The striking cases of the power of wind to heap water on coasts, and to move bodily great masses of it in lakes, are only interesting and relevant as demonstrating the sufficiency of wind-friction to produce broad and rapid surface-currents. This conceded, and the case is won, because, in the lakes and open ocean, like causes produce like effects. Wind of given velocity raises in both places waves of equal height in equal times: against these waves the wind presses in the direction of its flow, with no opposing force. As a consequence, the roughened water-surface, from greatly increased friction, is moved bodily forward just as though impelled by the paddles of a revolving wheel. This surface-flow is in time communicated to underlying strata, and, if the wind continue to blow in the same direction, ultimately a large body of water will be set in motion; in other words, an ocean-current will be produced. There is no escape from this conclusion; and all that part of Mr. Ferrel's paper which relates to wind-velocities, gradients, cross-sections, etc., are irrelevant. The great truth remains, that wind-friction can produce ocean-currents. The difference in specific gravity between cold arctic and warm tropical water is undoubtedly also a *vera causa*, the only difference between Mr. Ferrel and myself being as to the relative value of these two factors. Impressed as I am with

the palpable evidence of the tremendous efficiency of wind-friction, and realizing the extreme slowness of readjustment of disturbed equilibrium by a slight difference of specific gravity, the other factor, I am compelled to give in my adhesion to the party, very respectable in numbers and intelligence, who ascribe the greater efficiency to the friction of wind.

So far as the surface-gradients of the ocean are concerned, I must say that I regard them of no significance in this discussion. One has only to turn to Dr. Penk's 'Die schwankungen des meeresspiegels,' and read the record which he and the authorities he quotes have made, to see that along the coast sea-level is altogether a local phenomenon, and is dependent upon the altitude and position of the neighboring land-masses. Where the shores are lofty mountains, there the water attracted by them rises above the normal; it also rises on both sides of the Atlantic, and is probably ten or twelve feet lower in the middle than on either side.

J. S. NEWBERRY.

The genesis of the diamond.

Prof. Carvill Lewis, in his remarks on 'The genesis of the diamond' (*Science*, viii. p. 345), briefly alludes to the peridotite of Elliott county, Ky., as 'suggesting interesting possibilities.' My notes (*American journal of science*, August, 1886, p. 121) on this remarkable eruptive rock are but a brief digest of a report (Bulletin No. 38, U. S. geological survey, not yet published) in which its peculiar features are more completely described. If the hypothesis advanced by Professor Lewis really accords with nature's method of manufacturing this precious gem, it gives to prospectors a most valuable guide; and it is well worth while to carefully examine all localities the geological composition and history of which are analogous to that of the South African diamond-fields.

In Elliott county, Ky., near Isom's mill, six miles south-west of Willard, there are two short dikes of peridotite breaking through the horizontal sandstones and shales of carboniferous age in such a manner as to locally envelop many of their fragments. The slopes in the vicinity are well covered with soil, so that there are but few exposures of either the intrusive mass or the adjacent strata near the line of contact between them; and no considerable excavations have been made. Nevertheless it is evident that the shales have been distinctly metamorphosed by the peridotite. This is most plainly visible in the enveloped fragments of shale, which are quite numerous in the dike at one exposure near Isom's mill, but elsewhere they are almost or entirely absent. Thus both varieties of peridotite described by Professor Lewis occur in Kentucky, but the brecciated form has not yet been found to contain diamonds.

The dark shale, fragments of which are included in the peridotite, may be regarded as composed of sand and clay in varying proportions. The amount of metamorphism experienced by the small fragments of shale is very unequal, and by no means proportional to the sizes of the inclusions. One of the earliest and predominant metamorphic effects is the development of a micaceous mineral in the argillaceous cement. This development may extend so far as to render the inclusion chiefly micaceous. Each enveloped fragment is surrounded by a narrow zone of colorless mica, the scales of which are frequently arranged perpendicular to its surface. An advanced stage of metamorphism is marked by the appearance of very interesting spheroidal bodies with remarkably suggestive properties. They have a high index of refraction, and are pale yellowish to colorless, translucent to almost transparent, and completely isotropic. The diameter of these little globules is generally about .02 of a millimetre, and they are remarkably uniform in size. Rarely this substance appears in irregular grains; but generally it occurs in a form very suggestive of the diamond, for it resembles a hexoctahedron with curved faces. In general appearance it simulates the small translucent crystals of octahedrite in the adjacent peridotite, but their optical properties and action in acids readily distinguish it from that species. They are soluble in concentrated hydrochloric acid, and, when heated to bright redness, they become less translucent and somewhat earthy in appearance; but the change is not prominent. In the small fragments the globules are usually numerous, and scattered throughout the scales of clouded mica, but most abundant and least regular in form near the periphery of the inclusion, where they sometimes form quite a distinct border just inside the one of colorless mica. In the fragments where this peculiar isotropic substance is most abundant, there is but little well-developed mica. Notwithstanding the fact that some of their properties suggest that they are diamonds more or less perfectly crystallized, their solubility in acid renders such a view untenable. Were they diamonds, they would be of comparatively little value, because of their exceedingly small size.

The dark shale which is frequently enveloped by the peridotite is somewhat carbonaceous, but contains a small proportion of carbon as compared with that of the South African diamond-field: for this reason, it appears to me rather improbable that diamonds will be discovered at the locality in question.

Some very pretty pyropes, locally supposed to be rubies, have been picked up in the soil resulting from the decomposition and disintegration of the peridotite, but nothing of greater value has yet been discovered at that place. That the dikes have been prospected, and supposed to contain valuable metals, is evidenced not only by slight excavations, but also by the ruins of what appears to have been a structure for reducing ore. Nothing is known in that country of the history of these ruins, and they may be of considerable antiquity.

It appears to be a significant fact in favor of Professor Lewis's hypothesis, that the diamonds found in the United States have been discovered where peridotites abound. The chief localities are either in North Carolina and Georgia or in California. Of all the mountain-ranges of this country, the northern portion of the Sierras in California is perhaps the richest in serpentine. In cases I have examined, the serpentine is derived by alteration from peridotites. In the same region, among older stratified rocks of the auriferous series, is a black shale or slate which occasionally contains a considerable amount of carbonaceous matter; and it is quite possible that the diamonds which have been discovered in the Sierras had their origin along a contact between peridotite and carbonaceous shale. At any rate, the suggestion opens another field for prospectors, and it should be remembered that corundum, with its gems, is also found under similar geologic conditions.

J. S. DILLER.

Petrographic laboratory, U. S. geol. surv.,
Washington, D.C., Oct. 21.